San Francisco Estuary Invasive Spartina Project

Revegetation and Monitoring Plan

Prepared for submittal to

United States Fish and Wildlife Service
Don Edwards San Francisco Bay National Wildlife Refuge
and Ecological Services Division

by

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1. INTRODUCTION

1.1. Purpose of Document

This Revegetation and Monitoring Plan (RMP) describes the actions that the State Coastal Conservancy (State lead agency) and US Fish and Wildlife Service (Federal lead agency) will implement to accelerate establishment and reestablishment of native vegetation and habitat structure in tidal marshes of the San Francisco Estuary where invasion of non-native *Spartina* (including *S. alterniflora*, *S. densiflora*, *S. patens*, and *S. alterniflora* x *foliosa*) and its subsequent eradication have left marshes without a sufficient native vegetation component. A particular focus of the RMP is to increase native marsh vegetation and high tide refugia to benefit California clapper rail (*Rallus longirostris obsoletus*), a federal and state listed endangered species, consistent with the Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2010).

1.2. History and Effects of Non-native *Spartina* Invasion in the San Francisco Estuary

Smooth cordgrass (*Spartina alterniflora*), native to the Atlantic and Gulf coasts, was introduced to the east shore of San Francisco Bay by the U.S. Army Corps of Engineers in 1977 as part of a restoration experiment (U.S. Army 1978). The introduced grass hybridized with native California cordgrass (*Spartina foliosa*), and within a few generations, a highly fertile, and self-fertile "hybrid swarm" was moving into new areas (Sloop *et al.* 2008, Ayres *et al*. 2008), quickly invading and dominating every tidal marsh restoration project that had been initiated in the central and south bay since the 1980s (**Figure 1**; 47 projects totaling 1,600 hectares; ISP 2007a, 2007b, Ayres and Strong 2004a, 2004b). Many of the hybrid plant morphotypes were much taller than either parent species, produced bigger flowers with more seed and pollen, and could grow readily in areas where the native could not, forming dense, monotypic meadows. In addition to thwarting restoration efforts, the aggressive hybrids were encroaching on the bay's mudflats (Ayres *et al.* 2003a, 2008, Stralberg 2010), critical foraging habitat for local and migratory shorebirds and waterfowl (Goals Project 1999, SFBJV 2001), and moving into low- and mid-tidal marsh, displacing native cordgrass and other flora essential for the federally endangered California clapper rail and salt marsh harvest mouse (*Reithrodontomys raviventris*). Researchers concluded that the pollen swamping effect of the hybrids combined with its displacement of native biota placed the native cordgrass in "immediate danger of extirpation" in the San Francisco Bay (Ayres *et al.* 2003b,

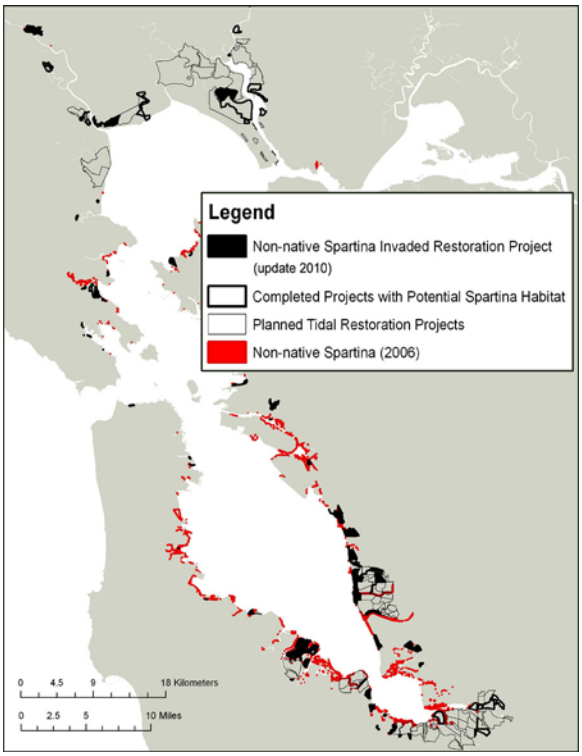


Figure 1. Map of Invasive Spartina distribution in 2006, invaded tidal marsh restoration sites as of 2010, and planned future restorations, at risk of invasion.

2004c).

Dense-flowered cordgrass (*S. densiflora*), native to South America, was introduced to the Corte Madera Creek watershed in Marin County in the 1970s, when it was mistaken for California cordgrass and planted in a restoration project. By 2005, dense-flowered cordgrass dominated the local tidal marsh restoration projects, and had spread the entire tidal reach of Corte Madera Creek. It was moving rapidly into tidal marsh preserves along the Marin shoreline, and spreading from this location to other areas in San Pablo Bay and further south into Central and South San Francisco Bay.

The introduction history of Salt meadow cordgrass (*S. patens*), native to the Atlantic and Gulf coasts, in San Francisco Estuary is unclear. So far it occurs in only one geographic region, Southampton Marsh in Suisun Bay, which may be the southern extent of its potential range. In this location, it appears to serve as a nominal host to the endangered hemiparasitic soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*), but it is also spreading and becoming more dominant through parts of the marsh, and may eventually displace the bird's beak. Salt meadow cordgrass has also been found to be extremely invasive in many other locations, and it could be an additional significant threat baywide, should it begin to migrate south of its current location.

1.3. Response to Non-native *Spartina* Invasion in the San Francisco Estuary

The State Coastal Conservancy and the U.S. Fish and Wildlife Service initiated the Invasive *Spartina* Project in 2000 to stop the spread of invasive cordgrass species within and from the Estuary, and to eradicate them, if that should prove possible. In 2004, the Conservancy hosted the Third International Conference on Invasive *Spartina*, and asked an invited panel of experts from California, Washington State, France, China, Tasmania, New Zealand, and the United Kingdom, who had been researching or battling invasive *Spartina* species for decades, whether and how to attempt the control of the hybrid *Spartina* invasion. The panel concluded that the hybrid *Spartina* invasion of San Francisco Bay was young by invasion standards, and there was a good chance it could be eradicated with an aggressive and coordinated effort (Ayres 2010). Because of the importance of salvaging the potential future restoration of a healthy tidal marsh ecosystem, the Invasive *Spartina* Project was fully funded by both the State and Federal agencies, and a coordinated, region-wide eradication effort was launched.

From 2000-2003, the State Coastal Conservancy and U.S. Fish and Wildlife Service conducted initial environmental planning and permitting work, resulting in the Final EIR/EIS issued in September 2003. The Federal Record of Decision was completed in September 2004, and a pilot year of treatment using Glyphosate herbicide was conducted at 12 sites during the limited treatment window from September to October. An improved approach to treatment that included the use of Imazapyr herbicide in the limited treatment window from September to October was conducted in 2005. Full-scale, effective control through the use of Imazapyr herbicide via aerial applications starting July 15 was initiated in 2006. Full-scale control began when the net area of invasive *Spartina* was greater than 800 net acres, distributed over many thousands of marsh acres. By the start of treatment in 2010, the program had successfully reduced the bay-wide population by 90%, to less than 100 net acres. It is anticipated that with continued control, up to 90% of the remaining 170 sites will have 'zero detect' (where no discernible non-native *Spartina* is found during yearly inventory monitoring) by 2013.

In most areas where non-native *Spartina* has been eradicated, the result has been rapid and large-scale return to a native-plant species dominated habitat at low- and mid-marsh elevations, and a

return to the natural mudflat and tidal channel conditions at lower elevations. As the marshes recover from the *Spartina* invasion over time, it is anticipated that historical vegetative complexity and density will be passively re-established in most marshes.

However, in some locations, particularly near the point of initial introduction and in areas where hybrids were intentionally transplanted, the hybrid cordgrass (and in one case, dense-flowered cordgrass (*S. densiflora*) had effectively displaced most of the native flora, such that the native marsh structure has been significantly damaged (**Figure 2**). This change to marsh structure has caused impacts to the endangered California clapper rail, and implementation of this Revegetation and Monitoring Plan provides compensatory mitigation by creating additional habitat to benefit rails.

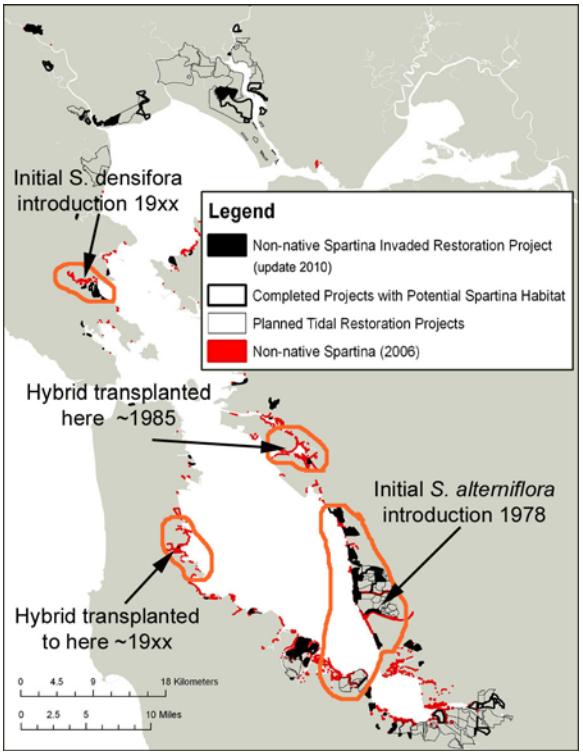


Figure 2. Areas of high impact from non-native Spartina domination of native habitat matrix. California cordgrass and other native plants were displaced by the non-native invader, and the areas are now devoid in seed and propagules sources to naturally regenerate in a reasonable time period.

1.4. Overview of Program Approach

The Coastal Conservancy proposes a revegetation program that will accelerate successional revegetation following successful non-native *Spartina* control at selected tidal marshes. The approach will be customized to each marsh, based on the existing conditions and the potential for successful revegetation. For example, many of the most heavily invaded marshes were restoration and mitigation projects opened to tidal flow between 1990 and 2005, where the aggressive hybrid *Spartina* quickly dominated the marsh and precluded other vegetation. In these areas *Spartina* control has 'reset' the "natural" vegetative development to an early successional stage, similar to what would have been present 2-5 years after the initial breach. These marshes tend to consist of perennial pickleweed (*Sarcocornia pacifi*ca), annual pickleweed (*Salicornia depressa*) and other low-growing, mat-forming plant species, with the missing component being *Spartina foliosa*. Some of these marshes are in proximity to *S. foliosa* populations, the native could reestablish "passively", without assistance. However, in many areas, such as San Leandro Bay and the Hayward and San Leandro shorelines, the geographic scope and density of the invasive *Spartina* effectively extirpated native cordgrass from broad areas, and the native will have to be introduced or reintroduced to the marsh by planting. There is, however, a significant risk associated with introducing *S. foliosa* where it may be pollinated by hybrid *Spartina*. The hybrid produces a much greater volume of pollen than the native, and effectively swamps the native flowers, producing hybrid seed which continues to spread invasively. Thus, great care must be taken in choosing locations for *S. foliosa* planting, and in monitoring planted areas for any signs of invasive hybrid behavior.

Another aspect of the revegetation plan is to augment other native plant species within the tidal marsh plain and in adjacent upland areas, where it will enhance refugia for California clapper rails. While these plants are not in danger of being pollinated by hybrid *Spartina*, they would be

at risk of being damaged during *Spartina* control work, so care must be taken to time these plantings as well, and to coordinate plantings with treatment planning.

The Invasive *Spartina* Project began planting marsh gumplant (*Grindelia stricta*) via seed and seedlings at selected marshes in 2006 and 2007, and pilot projects for replanting *Spartina foliosa* began in 2010 (Figures 4-8). These projects are being monitored and assessed, and the results will be used to inform the future revegetation efforts.

2. REVEGETATION PROGRAM GOALS AND OBJECTIVES

The over-arching objective of the Revegetation Program is to establish, as rapidly as possible through active revegetation and continued non-native *Spartina* control, approximately 50 acres of estuarine intertidal emergent wetland habitat. Continued control of non-native *Spartina* will allow for passive revegetation of all marshes where non-native *Spartina* control occurs, which represents more than 95% of the revegetation that will take place in these areas. Both of these revegetation activities, active and passive, will be managed with the intent to re-establish habitat suitable for California clapper rail occupancy, where feasible.

2.1. Program Objectives

1. Enhance and accelerate *S. foliosa* re-establishment at selected marshes through introduction of plugs or propagated seedlings that will support associated faunal communities including clapper rail foraging and nesting habitat.
2. Enhance and accelerate post-treatment marsh succession and complexity with introduction of other native marsh plant species (such as *G. stricta , Triglochin maritima,* and others), which have a tall shrubby structure that will provide clapper rail nesting substrate, cover and high tide refugia.

2.2. Specific Program Goals

1. Coordinate with Invasive *Spartina* Project Partners and Estuary-wide restoration groups to collaborate on revegetation methods, monitoring, planting and public education programs for long-term success.
2. Conduct science-based revegetation projects that use best methods and planting scenarios for *G. stricta, S. foliosa* and other suitable tidal marsh plant species as appropriate.
3. Coordinate significant revegetation efforts on a variety of sites, building on knowledge gained from previous smaller-scale Phase I pilot revegetation efforts from 2006-2010, and Phase II pilot revegetation efforts from 2011-13.
4. Comprehensively monitor planting efforts, including:
    - Genetic screening of donor plant populations
    - GPS mapping of planting sites
    - Monitoring of planting survivorship, planting method assessment, habitat assessment and spread of both passive and active revegetation.
    - Genetic monitoring of areas planted with *S. foliosa*
    - Clapper rail monitoring through ISP and partners call count surveys

- Maintain planted areas (e.g., re-planting, weed control) to assist in survivorship of plantings through at least the first 5 years post-planting
- Adaptively manage plantings to maximize potential clapper rail benefits

2.3. Research and Management Questions

Existing pilot revegetation projects have been designed to answer several of the questions listed below and this information has been incorporated into the revegetation design and data collection that is currently underway. Revegetation projects during the next two seasons (winter 2011 through spring 2013) will continue to provide additional information.

Collection and Propagation

- What are the most appropriate donor populations for *S. foliosa*?
- What are the most effective collection times?
- Do collection site conditions affect propagation vigor and transplant survivorship?
- What is the most efficient and cost-effective propagation method for target species?
- What acclimatization (salt hardening) technique maximizes transplant survivorship?

Coordination

- Identify nurseries and/or collaborative partnerships best qualified for collection, propagation and planting.
- Identify funding sources.
- How does the revegetation effort maximize public awareness and involvement?
- What other non-profit organizations and private firms are best suited to aid in the revegetation effort?
- What organizational structure is best suited for implementing the revegetation program?

Planting

- What are the baseline conditions of selected marshes?
- Which site selection criteria are most likely to achieve the goals of the revegetation effort?
- How does seedling/plug size relate to survivorship?
- Which microhabitats within target marshes maximize survivorship of plantings?
- What are the most effective planting times?
- Is caging a cost-effective means of enhancing transplant survivorship vs. replanting?
- Do large, mature *G. stricta* plantings experience survivorship rates similar to plugs across microhabitat types?
- Do soil amendments enhance short and/or long-term survivorship of plantings?
- How does introduction of small woody debris affect survivorship of transplants?
- How does diversity of planting affect survivorship of transplants?
- How does planting density affect survivorship of transplants?

Monitoring

- How does a passively revegetated site compare to an actively revegetated site?
- How do actively revegetated sites compare to reference sites?
- How do clapper rail respond to transplant methods and layout?
- What is the best means of collecting information from partners?
- What is the best means of communicating results to stakeholders?
- How do we best structure a monitoring plan?

3. PROGRAM APPROACH

3.1. Structure and Scope

In order to facilitate successful implementation of the project goals, the revegetation effort will be centrally coordinated and scaled relative to the area available for direct plantings. Initial pilot project work and full-scale implementation of propagation, seed and plant collection, planting, monitoring and maintenance was begun in 2006, and lessons learned from these projects will be applied to a scaled-up approach to revegetation at additional sites. The revegetation work is aimed to maximize the ecological benefit of the effort in the shortest possible timeframe, with lasting and self-perpetuating positive outcomes.

3.2. Program Background

Pilot projects have been underway since 2006, involving multiple, diverse partners at several sites and providing the basis for expected success with the scaled-up full revegetation approach described in this proposal. The pilot efforts include upland transition zone plantings with Save The Bay and East Bay Regional Park District at three sites within the Martin Luther King, Jr. Regional Shoreline in San Leandro Bay: Arrowhead Marsh, Martin Luther King, Jr. Restoration Marsh, and Damon Slough. Save The Bay has also worked with the California Department of Fish and Game at the Eden Landing Ecological Reserve in Hayward to pilot upland transition zone plantings along levees of newly opened salt ponds within this site. The Friends of Corte Madera Creek has worked closely with the Marin County Department of Parks and Open Space and the Marin County Public Works Department, to implement mid-marsh plantings at Creekside Park along Corte Madera Creek in San Rafael (2011-2012). The Invasive *Spartina* Project staff conducted pilot broadcast seeding efforts in 2006 at Cogswell Marsh, Oro Loma Marsh, and Elsie Roemer Marsh; channel reconstruction and native mid-marsh plantings in 2006 at Elsie Roemer Marsh on Alameda Island; and pilot *S. foliosa* plantings in January 2011 at Elsie Roemer Marsh and along Colma Creek. These and other similar revegetation projects are being monitored to assess techniques and success, and provide valuable data and lessons learned that will be applied to a scaled-up approach to revegetation at up to 39 sites from 2011-2016.

Building on the recommendations of the 1999 San Francisco Baylands Ecosystem Habitat Goals Project, the State Coastal Conservancy has been a primary partner in multiple large-scale wetland restoration projects in San Francisco Bay, including the South Bay Salt Ponds Project, Hamilton Field, Sonoma Baylands, Napa Sonoma River Marshes, and dozens of other sites. In addition, the Coastal Conservancy has provided funding to multiple small revegetation projects conducted by local agencies, grassroots creeks groups, community-based restoration programs, and

private revegetation contractors. The Coastal Conservancy is committed to securing state bond funding (pending Conservancy Board approval at the September 22, 2011 Board meeting) for 2011-13 "Phase II" revegetation approaches at Arrowhead Marsh and up to nineteen other sites. These pilot projects will result in improved habitat at each of the locations, in addition to providing data to inform the best approaches for the additional revegetation efforts.

The Coastal Conservancy and its partners will continue implementing a revegetation management structure that will:

- Implement detailed work plans in coordination with all regional partnerships (U.S. Fish and Wildlife Service, California Dept. of Fish and Game, East Bay Regional Parks District, Save The Bay, Friends of Corte Madera Creek, California Wildlife Foundation, revegetation contractors, local native plant nurseries, etc.)
- Coordinate planning, implementation, monitoring and maintenance activities
- Produce documentation necessary for Federal and State permitting of activities
- Obtain individual site access permissions
- Set up revegetation contracts and conduct planting events led by trained experts
- Implement a limited number of planting events with volunteers
- Direct in-field training and oversight of volunteers and contractors
- Schedule and coordinate monitoring and maintenance activities
- Produce yearly reports on revegetation progress based on success criteria
- Adaptively manage the program to modify approach based on project-generated results

4. PROPOSED REVEGETATION SITES

A systematic approach was used to select the sites at which revegetation would be both useful for enhancing wildlife support, and potentially successful, based on site conditions. The approach entailed identifying types of sites that could be revegetated and why, establishing criteria by which sites of suitable types could be selected and then ranked for priority. This process, and the resulting list of sites, is described in this section.

4.1. Site Types

Three general types of sites have been defined as the priority for active native plant revegetation, including:

Type I sites consist of new marshes that are generally lacking in vegetative cover; these may be recently breached sites or may be slightly older restoration marshes that were dominated by hybrid *Spartina* and extensive treatment has returned them to a state similar to before the invasion. While *Sarcocornia pacifica* may colonize these sites at an adequate rate, it is unlikely that *S. foliosa* or *G. stricta* will establish significant cover in the short term without active revegetation assistance. These sites are generally wide open with lots of open mud; while they have great potential to support special status species like clapper rail and salt marsh harvest mouse in the long term, most currently do not.

Type II sites are more mature than Type I sites, with a developed marsh structure and complex geomorphology. These sites tend to be fully vegetated with *Sarcocornia pacifica*, with a minor presence of sub-dominant native plants (e.g., *Jaumea carnosa, Frankenia salina, Distichlis spicata*). Hybrid *Spartina* dominated most of these sites prior to treatment, clogging the sinuous tidal channels and overtaking the marsh plain with a near-monoculture of tall, dense cordgrass. As hybrid is approaching eradication, it is appropriate to begin native *S. foliosa* re-introduction since the new plantings will not undergo pollen-swamping resulting in production of hybrid seed that could expand the infestation.

These sites generally have good interior channel structure to enhance and so would also be good candidates for *G. stricta* plantings along the well-drained channel banks. Type II sites often still support a small remnant population of clapper rail and presumably salt marsh harvest mouse, so these species would benefit quickly from the establishment of these vegetation enhancements.

Type III sites encompass a variety of special sites that do not fit into the other two site types but that meet the Goals above and the Site Selection Criteria spelled out below. This category includes sites related to large flood control channels that were dominated by hybrid *Spartina* monocultures and received broadcast aerial applications for several years to reduce them to a level that could be managed on the ground. There was no native *Spartina* remaining at these sites because of the infestation, and removal of the hybrid has left them without the vital cordgrass component needed for a fully productive tidal marsh community. The sites are in various stages of passive revegetation, from sparse colonization and areas of open mud to widespread establishment of *Sarcocornia pacifica*.

Another category of marshes that are included in Type III are small sites with a decent baseline condition where the hybrid *Spartina* monoculture has been eliminated, and the marsh is in close proximity to higher quality habitat that could export clapper rail and eventually increase the population in that Bay region.

4.2. Site Selection Criteria

To choose a reasonable subset from among the possible locations around the Bay that may benefit from planting, ISP developed the following site selection criteria:

- Potential to revert to pre-treatment native marsh complexity and function with or without revegetation efforts
- Distance from incomplete control of non-native *Spartina*
- Size of marsh complex to be revegetated: larger sites preferred over smaller for greater ecological benefit
- Proximity to other marshes or marsh complexes
- Potential to serve as an incubator or hub and act as a seed source to adjacent marshes
- Distance from donor plant populations; weighing the potential of the site to passively revegetate with desired species in the near term without active assistance
- Post-treatment presence of native *Spartina* component of marsh.

Based on the above criteria, 39 sites were selected for consideration and prioritization (**Table 1**).

Table 1: Sites Selected for Revegetation Efforts

Type I Sites (n=12)	Type II Sites (n=14)	Type III Sites (n=13)
Cargill Mitigation Marsh (13f)	Ideal Marsh South (21b)	Alameda Flood Control Channel Mouth, Lower and Upper Channel (01a-01c)
Eden Landing – North Creek (13h)	Whale's Tail South (13e)	Old Alameda Creek North Bank, Island & South Bank (13a-c)
Eden Landing – Mt. Eden Creek (13j)	Seal Slough Mouth (19p)	Fan Marsh (17j)
Eden Landing – North Cr. Marsh (13k)	Pond 3 – AFCC (1f)	Belmont Slough Mouth (2a)
Eden Landing – Eden Cr. Marsh (13l)	Cogswell Quads A, B, & C (20m-o)	East Creek (17d)
Oro Loma East & West (7a & 7b)	Citation Marsh, North Marsh, Bunker Marsh (20d, f, g)	Colma Creek (18a)
Elsie Roemer (17a)	Arrowhead Marsh (17c)	Navigable Slough (18b)
MLK Restoration Marsh (17h)	Creekside Park (4g)	San Lorenzo Creek Mouth (20h
San Bruno Marsh (18g)	Damon Marsh (17d)	Dogbone Marsh (20c)
Confluence Marsh (18f)	Greco Island North (2f)	
Southampton Marsh (11)		

4.3. Site Ranking Criteria

Based on the site selection criteria, the State Coastal Conservancy has identified 39 sites where revegetation would provide a substantial benefit. Since both planning time and funding need to be carefully planned and prioritized, these sites have been evaluated against a standardized set of criteria to determine the most effective strategy and top priorities for the 39 identified sites. The State Coastal Conservancy has developed a number of "ranking criteria," as well as a proposed process for conducting the ranking.

Each site ranking criteria are scored from one to five, with a score of 'five' assigned to those sites that fully meet a criterion and 'one' to those that do not. **Table 2** defines the ranking criteria for the sites. The ranking criteria were applied to the 39 potential revegetation sites, resulting in the relative ranking shown in **Table 3**.

4.4. Revegetation Reference Sites

Reference sites are valuable tools in restoration, providing models for comparison that can be used to set goals for various aspects of a project ranging from simple presence/absence data to the performance of complex ecological functions. The primary dilemma with the selection of a reference site stems from the absence of "pristine" areas, especially around major urban centers. Virtually all areas have been impacted by human development, normally to a high degree, and each type of impact presents new variables to reconcile. This is certainly true when considering tidal marshes in San Francisco Bay, and the State Coastal Conservancy acknowledges that no single site will provide a perfect baseline for comparison of the revegetation goals.

Table 2: Site Ranking Criteria

Criteria # in Table	Criteria	Ranking in Table				
		1	2	3	4	5
1	**Proximity of *S. foliosa* to the site**	*S. foliosa* established at current site	Substantial *S. foliosa* established at complex	Little *S. foliosa* established at complex	Distant *S. foliosa* in area, passive dispersal to site unlikely	None within complex/area
2	**Hybrid *Spartina* fully controlled at/around the site such that pollen swamping of the native will not occur**	Significant hybrid within the site		Moderate hybrid within site/complex, can be controlled ahead of flowering		Very little hybrid within complex/area
3	**The site is large**	Small site (<10 acres, CLRA habitat area)		Medium site (50-100 acres)	(100-200 acres)	Large site (> 200 acres)
4	**Site is part of larger marsh complex such that investment could provide greater ecological benefits after revegetation is established (propagule dispersal)**	Small isolated site	Medium isolated site	Small site within complex	Large isolated site	Large site within complex
5	**Clapper rail (CLRA) present or immediately adjacent to site that could readily occupy revegetated area**	Already support high density CLRA populations in native marsh	NO CLRA within area	CLRA, within complex (not at site) low density	CLRA, within complex high density	CLRA, within site
6	**There is little to no *G. stricta* at the site but appropriate elevation/drainage for the species**	N/A	Some edges	Edges	Edges and some interior	All suitable elevation zones available
7	**There is an elevation gradient at the site that allows for transition zones and high tide refugia**	No elevational gradients/ steep engineered transition zones	Little elevational gradients/narrow (engineered) transition zones	Moderate elevational gradients/ engineered transition zones	Moderate elevational gradients/ wider engineered transition zones (e.g., 1:5 slope ratio)	Extensive elevational gradients/ natural transition zones
8	**Active revegetation may help to provide biotic resistance that could preclude invasion of the site by neighboring weed infestations**	Nominal invasion pressure from neighboring high marsh transition zone weeds		Moderate invasion pressure from neighboring high marsh transition zone weeds		Extensive invasion pressure from neighboring high marsh transition zone weeds
9	**Site is ready to move forward in terms of active partnerships, funding, etc.**	No active partnerships, funding, etc.		Active partnerships, no/partial funding, etc.		Active partnerships, funding, etc.
10	**Site has an established marsh structure including well-defined channels**	No or little established marsh structure or channelization		Moderate established marsh structure or channelization (lacking high order channels)		Extensive established marsh structure or channelization (including higher order channels)
11	**Site is newly opened or has been returned to an early stage of succession by elimination of previously-widespread hybrid *Spartina***	Native condition: extensive, mature marsh vegetation or mudflat habitat		Moderately developed marsh vegetation		No/little vegetation.

Table 3: Site Ranking Results

Site Type	Site Name (Site Code)	TOTAL SCORE
Type I (n=12)	Cargill Mitigation Marsh (13f)	40
	Eden Landing – North Creek (13h)	35
	Eden Landing – Mt. Eden Creek (13j)	46
	Eden Landing – North Cr. Marsh (13k)	44
	Eden Landing – Eden Cr. Marsh (13l)	43
	Oro Loma East & West (7a & 7b)	45
	Elsie Roemer (17a)	34
	MLK Restoration Marsh (17h)	36
	San Bruno Marsh (18g)	35
	Confluence Marsh (18f)	32
	Southampton Marsh (11)	n/a
Type II (n=14)	Ideal Marsh South (21b)	46
	Whale's Tail South (13e)	47
	Seal Slough Mouth (19p)	42
	Pond 3 – AFCC (1f)	38
	Cogswell Quads A, B, & C (20m-o)	42
	Citation Marsh, North Marsh, Bunker Marsh (20d, f, g)	44
	Arrowhead Marsh (17c)	33
	Creekside Park (4g)	39
	Damon Marsh (17d)	33
	Greco Island North (2f)	43
Type III (n=13)	Alameda Flood Control Channel Mouth, Lower and Upper Channel (1a-1c)	43
	Old Alameda Creek North Bank, Island and South Bank (13a-c)	45
	Fan Marsh (17j)	34
	Belmont Slough Mouth (2a)	32
	East Creek (17d)	29
	Colma Creek (18a)	36
	Navigable Slough (18b)	34
	San Lorenzo Creek Mouth (20h)	n/a
	Dogbone Marsh (20c)	n/a

While the Invasive *Spartina* Project Revegetation Program is intended to align marshes with the right trajectory for reaching a diverse, sustainable habitat for all denizens of the tidal marsh, one particularly important target is to provide habitat conducive to supporting the endangered California clapper rail, and this goal will inform the reference sites to be selected. Creating conditions that are favored by clapper rail will also have the indirect effect of creating an active seed source for some key plant species that can disperse within a site or marsh complex, and can potentially export seed to surrounding areas.

With these goals in mind, the reference site selection process begins with a review of recent clapper rail call count survey numbers that have been compiled by Invasive *Spartina* Project clapper rail program staff, PRBO Conservation Science, USFWS, Avocet Research Associates and others. Candidate reference sites will be selected from sites with a consistently high density of rails over multiple years, an indication of the presence of stable, high-quality habitat that allows the population to successfully breed and thrive. Sites that were heavily invaded by hybrid *Spartina* would be eliminated from consideration because the presence of dense stands of this non-native plant tend to elevate clapper rail numbers in the short to medium term; therefore, the population of clapper rails in that case is not an indication of the health of the native plant community present at the site.

The State Coastal Conservancy has included three different marsh types (as defined above) in the revegetation plan. Type I includes newly restored sites that will not have the mature structure and established plants of Type II sites. Although the vegetation community characteristics of the high-density rail sites can still be used at Type I sites to guide planting and gauge long-term success, a set of younger reference sites will also be selected to compare the rate of plant colonization and other parameters. This may inform a realistic timeline of what to expect from the revegetation enhancements in the short- and medium-term as the marshes start to establish. Two sites that could serve this purpose are the Island Ponds and Sonoma Baylands.

The data collected at the reference sites will be used to inform the quantification of success criteria and help to determine progress toward goals. Since this is an adaptively managed project, vegetation monitoring at revegetation sites can inform any changes or enhancements that could be implemented to produce the desired habitat functions.

Reference sites are not intended to be tied to success criteria, rather they are intended as resources to document habitat structure and composition; reference sites may be used to guide planting design, and for comparison in the event that adaptive management is required.

5. TIMELINE

The State Coastal Conservancy's Invasive *Spartina* Control Program has a main window of treatment activity that runs from May through early October of each year. The typical planting calendar for tidal marsh plants around the San Francisco Estuary is from November through March to take advantage of seasonal rains, lower salinity conditions, and cooler weather which all favor successful establishment of plantings. The two timeframes are perfectly dovetailed such that revegetation work will follow the *Spartina* treatment season directly for the duration of the active revegetation effort. Further, the initial pilot project effort outlined briefly in the following section would almost directly mimic the pilot project work done by the *Spartina* Control Program at the outset of the program in 2004: limited in scale, but aimed to identify issues related to implementation, cost, permitting, methods and approach that could be translated into the larger effort in subsequent seasons.

The proposed structure of the coordinated revegetation effort would build on the existing program structure and approach of the Invasive *Spartina* Project, utilizing the field and technical expertise of the *Spartina* Control and Monitoring program staff. The Invasive *Spartina* Project has also added a part-time Restoration Program Manager with dedicated time for technical planning, coordination, monitoring, and reporting. Following this successful model will save substantial time and money involved in developing a new structure, and utilizes the Project's existing skill set, specialized equipment, and experience.

Activities associated with the revegetation plan will occur year-round. Monitoring, planning and maintenance activities will be scheduled throughout the year, whereas planting will generally occur during the rainy season, roughly from November through March.

- **Short Term (July 2011 - March 2012)**
  - Develop pilot project series.
  - Grow and plant a selection of species to include:
    - *G. stricta,* in appropriate numbers
    - *S. foliosa*, in appropriate numbers
    - Potentially *Distichlis spicata and others*
    - Potentially *Triglochin maritima,* in appropriate numbers
  - Establish a strong monitoring program to answer key questions on best density, spacing, elevations, etc. for planting success.
  - Begin developing site-specific revegetation plans and budgets for the priority sites.
  - Work with USFWS, Save The Bay and others to develop general and site-specific (where possible) performance objectives and associated monitoring protocols.
  - Establish a revegetation partnership network.
  - Establish ISP Revegetation Program Technical Advisory Committee.
- **Medium Term (April 2012 – March 2014)**
  - Implement large-scale revegetation plans at priority sites using revegetation methods determined by pilot projects to be most effective.
  - Refine monitoring methods.
  - Continue to prepare and refine site specific revegetation plans for the rest of the priority sites.
  - Refine and expand revegetation efforts, both at current sites and additional new sites each year.
  - Maintain planted areas (including weed/herbivore control as necessary).
  - Refine and expand revegetation partnership network.
  - Refine ISP Revegetation Program Technical Advisory Committee.
- **Long-Term (2015-2020)**
  - Continue to monitor and maintain sites, measuring performance against the approved objectives.

- Previous plantings should be successful and much of the planted areas should be self-perpetuating. Modify management methods, augment plantings or take additional corrective actions as needed to meet performance objectives.
- Refine revegetation partnership network.
- Refine ISP Revegetation Program Technical Advisory Committee.

6. GENERAL PLANTING PLAN

There are a variety of potential active revegetation projects listed in this document that are being evaluated to achieve the goals described in the Goals section. Some of these projects will provide habitat enhancement that can be accomplished with volunteer field labor by groups like Save the Bay, and these projects tend to be located in the high marsh or along the upland ecotone. However, many of the potential projects are focused on the interior of the marsh where a higher level of expertise would be required. As the scale of the revegetation effort increases, some work will need to be conducted by contracted teams of trained professionals to maximize efficiency and limit impacts to existing marsh vegetation.

The active planting work proposed in this plan will be augmented by the natural, passive revegetation that occurs in all tidal marshes, and especially those treated for non-native *Spartina*. Historically, most revegetation of salt marshes in the San Francisco Estuary has exclusively relied on passive recruitment of propagules present in the waters of San Francisco Bay. Very little active revegetation has been proposed, and very little monitoring data exist.

In San Francisco in the 1970s, *S. foliosa* planting success was a frequently used metric for mitigation success (Williams and Faber 2001). Since the late 1980s, only smaller scale *S. foliosa* restoration has been attempted in the San Francisco Bay. This is due to both the limited success of some restoration efforts (Race 1985, Williams and Faber 2001), and because natural recruitment of *S. foliosa* was occurring without large scale planting efforts (Race 1985, Williams and Faber 2001). Additionally in sites near the hybrid *Spartina* invasion, best marsh practices have advised against *S. foliosa* planting (ISP 2006). That being said, there is a large body of work on *S. foliosa* restoration that exists for both smaller scale projects and the larger scale Army Corps of Engineers projects of the 1970s. This research is found in the form of government documents, reports, and unpublished theses. These projects will be used to inform planting design where appropriate.

Within selected marshes there will be four general revegetation zones which will be analyzed through Geographic Information Systems (GIS) analysis and ground-truthing, to determine best planting layout. General descriptions of these zones are:

(1) High marsh channel edge - 1-meter wide *G. stricta* zone for channels at higher elevation for high tide refugia, nesting & cover;

(2) Mid-marsh zone (possible planting palette: *Distichilis spicata, Triglochin maritime, Frankenia salina*, *Scirpus maritimus/Bolboschoenus maritimus;*

(3) Low marsh channel edge - 2-meter wide *S. foliosa* planting zone for channels at lower elevation;

(4) Upland transition zone: 1-meter wide *G. stricta* zone around levees and upland islands for high tide refugia & nesting (possible planting palette: *Artemisia californica, Baccharis pilularis/douglasii, Rosa californica, Rhamnus sp., Salvia sp., Mimulus sp. Eriogonum sp., Achillea millefolium, Sambucus nigra, Scrophularia californica?*;

(5) Low marsh zone - 2 to 10-meter wide *S. foliosa* fringe for lower elevation/wide channels, and

(6) High marsh zone: 1-3 meter upland transition zone plantings for high tide refugia (possible planting palette: *Artemisia californica, Baccharis pilularis/douglasii, Rosa californica, Rhamnus sp., Salvia sp., Mimulus sp. Eriogonum sp., Achillea millefolium, Sambucus nigra, Scrophularia californica*).

These general zones have been analyzed in GIS across five sites to estimate a total percent area capable of being actively revegetated in the marshes. Preliminary results indicate that roughly 3% of the entire site area is appropriate for active revegetation. This needs to be further analyzed and refined in creating site-specific planting plans. Due to issues of scalability and potential impacts associated with revegetation activities, the State Coastal Conservancy has proposed 1.5% (half of 3%) of the selected marshes' clapper rail habitat area may be revegetated. Using this 1.5% figure, across all sites, we estimate actively revegetating 49.72 acres.

S. foliosa planting will generally be planted at the edge of interior marsh channels as *S. foliosa* grows most robustly when in areas of daily tidal flushing. *S. foliosa* may also be planted at a variety of locations throughout the marsh plain as long as the elevation is appropriate, including a gradient along larger tidal sloughs or fringe areas along the Bay shore. The two main plant species that are absent from the selected revegetation sites or need enhancement to provide better wildlife support through dense canopy and shelter areas are *S. foliosa* and *G. stricta*. These plants have specific marsh elevations and inundation tolerances that will dictate appropriate locations for planting.

At Type II sites, S. foliosa planting will be primarily focused on reintroducing or enhancing this species along the interior marsh channels, planting just below the top of the banks. In addition to providing a source population within sites or marsh complexes that no longer have a native cordgrass component, these plantings can provide valuable foraging habitat for clapper rail as well as a monocot with which they can construct their nest structures. At Type I and Type III sites, *S. foliosa* may be planted at a variety of locations as long as the elevation is appropriate, including a gradient along larger tidal sloughs or fringe areas along the Bay Shore.

G. stricta plantings at Type II sites will complement the reintroduction of *S. foliosa* along channels, with *G. stricta* planting along the top of the banks and the cordgrass immediately below. Once the plants are established they have the potential to provide nesting habitat for clapper rail as well as some degree of high-tide refugia. *G. stricta* is also appropriate for planting along either the high marsh zone or the lower edge of the upland transition zonezone. Higher marsh edge is not present in significant amounts within the marsh proper, though well-drained channel edges may provide suitable substrate for *G. stricta* within the marsh at all three of the site types specified in this plan.

To achieve the maximum benefits of planting as rapidly as possible, a high-density planting configuration will be used for either the *S. foliosa* or *G. stricta* plugs. Plantings of other species will also be aimed at rapid establishment. As a general layout for *G. stricta*, the perimeter of an isosceles triangle imposed on the channel banks, 0.5 m per side, will be used as a guide. *G. stricta* will be installed at the points of the triangle; two plants parallel to the bank at 0.3 m from the channel bank and one plant offset away from the channel 0.8 m from the bank edge (**Figure 3**). This planting configuration requires four plants (3 + ½ + ½) per meter of channel per bank. Eventually the most successful of the plants may exclude their neighbors or limit their growth, but in the short-term the density provided by even the young plants could provide valuable bene-

fits to wildlife, and will create a greater in-marsh seed source that can disperse naturally to other appropriate areas of the site.

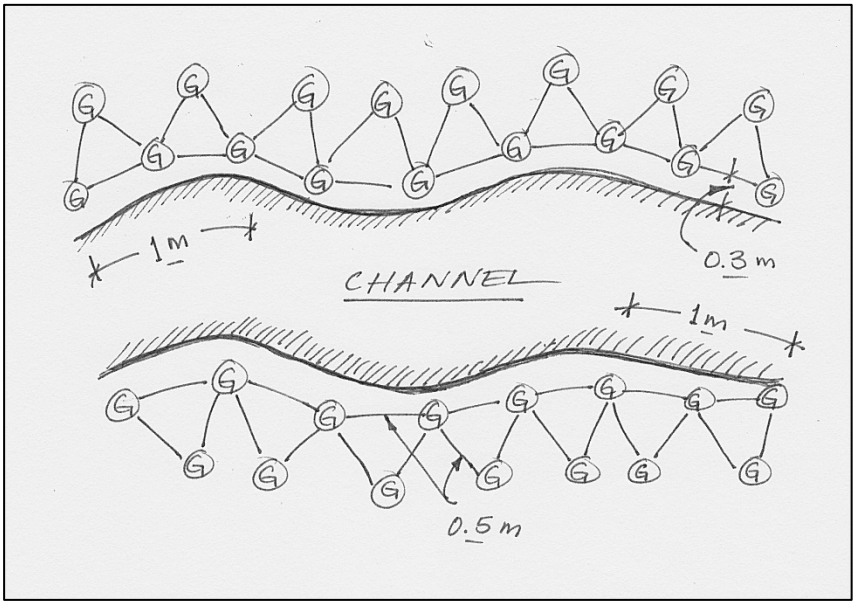
As part of the initial pilot project work, *G. stricta* planting may also involve the use of larger, more mature plants to increase survivorship and allow for more rapid establishment of seed-producing individuals (though more mature plantings may experience greater transplant shock). Spacing of transplants would be similar to smaller out planted plugs, but could be modified as necessary. Additionally, mature plants or seedlings may be interplanted with dead 'small woody debris' like harvested *G. stricta* skeletons or *Baccharis pilularis* cuttings anchored to the marsh substrate. This interplanting may provide temporary structural diversity to the marsh or channel edge. This may aid in passive seedling recruitment by increasing surface roughness which reduces wave energy, as well as providing shelter or nesting substrate to clapper rail in the short term.

For within-channel planting of native *S. foliosa*, a linear planting pattern would be used for smaller channels where there would not be sufficient space at the proper elevation to have a second, offset row. For smaller scale efforts, plugs will be harvested from the nearest feasible marsh free of non-native *Spartina* hybrids. For larger scale efforts, plants will be grown from seed, rhizome fragments, or whole shoots at a nursery. The individual plants would be installed every 0.5m on center, again to establish a dense stand of native cordgrass as rapidly as possible before the plants are old enough to expand vegetatively to a significant degree. This planting configuration requires two plants per meter of channel per bank. *S. foliosa* plantings in larger channels or along the hydrologic gradient of flood control channels could be installed in a similar pattern to the *G. stricta* described above, possibly even with a third or fourth row at sites with a shallow slope up to the pickleweed plain elevation.

To implement these general planting patterns, every 100m of channel would require:

- 800 *G. stricta* installed on both banks using the two-row configuration
- 400 *S. foliosa* installed below both banks within existing channels in a single row configuration

Figure 3: General Layout of *Grindelia stricta* Plantings along Channel



Planting layouts and strategies for these and other species will be developed with Save The Bay, East Bay Regional Park District and others. **Table 4** provides information from the literature regarding physical requirements of some salt marsh plant species.

7. MONITORING AND SUCCESS CRITERIA

The Coastal Conservancy proposes a number of general short, intermediate, and long-term "success criteria" or "performance objectives" to facilitate adaptive management and measure the success of revegetation projects across sites. Project performance relative to the success criteria will inform the next year's revegetation efforts, and will be provided to USFWS for annual review through the Section 7 Endangered Species Consultation for the site (Biological Opinion) and through reports produced by the State Coastal Conservancy.

Initial programmatic steps will involve establishing the necessary framework for ongoing revegetation of the proposed sites. The successful formation of a revegetation network, planting plans, secured funding, propagation and actual planting efforts (including all main target species) in 2011/2012 will be considered successful outcomes for the first revegetation season. Through

Table 4: General notes on Elevation, Salinity and Propagation of Typical Salt Marsh Plant Species Used in Revegetation.

Species	***Typical vegetation elevation***	***Salinity tolerance***	***Propagation notes***
Distichlis spicata	0.7 m+ NGVD	Requires freshwater flushing for establishment, but can be found a 45 ppt salinity in summer.	Establishes easily from rhizome cuttings, grows well in sandy substrates.
Frankenia salina	0.8-1.5 m NGVD	Seeds require freshwater for germination. Longevity of stems responds to water availability.	Seeds establish if germinated in fresh water. Field establishment best with seedlings, plugs, root cuttings.
Grindelia stricta	Appx 0.8+ NGVD.	0-25 ppt (in winter)	Seeds and plugs have both been used. Requires salinity hardening.
Bolboschoenus maritimus	Appx 1.0 + NGVD. (MHW)	0-20 ppt. Best at lower salinities.	Field establishment has highest success with plug planting in early winter.
Spartina foliosa	0.47 to 1.14 m NGVD	10-32 ppt, stunted at high salinities.	Propagates best from plugs.
Triglochin concinna	0.8- 1.3 NGVD	Requires planting during early winter rains. Dies back during summer, but can be dormant at high salinities.	Field establishment best with field planting of both plug and seed.
Triglochin maritima	0.8 m+ NGVD	In studies on East Coast, this plant is common on salt pan edges-this suggests high salinity tolerance.	Field establishment best with field planting of both plug and seed. Planting should occur early winter.

experimentation, the best methods of planting will be determined in order to improve survivorship at a high rate relative to the number of plants installed. An acceptable level of success in this regard would be on the order of >40% survivorship.

Plant survivorship is highly dependent on year of planting, site characteristics, and microhabitat. Thus, plant survivorship at the site level is expected to vary for initial plantings. An early restoration project (1969-1974) at Faber Marsh in Palo Alto had 57% survivorship of 441 *S. foliosa* plug plantings after 2 years (HT Harvey, internal memo) caused higher than expected plant mortality. Ward (pers comm.) reported high survivorship initial planting of *S. foliosa* at Crissy Field in the 2000s. Hydrology problems later Race (1985) wrote a critical review of *S. foliosa* restoration projects which called into question the success of these mitigation projects. She asserted that 90 percent of *Spartina* plantings had died out within the first 2 years of planting. Harvey and Josselyn (1986) refuted these claims, stating that Race had mistakenly assumed experimental plantings were equivalent to restoration. Survivorship of plantings done under this plan may prove to be irrelevant, as plants that experience mortality will be replaced.

In the *medium-term*, the rate of growth and maturation of the plants is a measure of the success toward providing the intended habitat enhancement. If the plants just survive but fail to thrive and reach a mature size, they won't provide the density needed to support target marsh wildlife species. In addition, plantings that are not thriving will not export sufficient seed to other areas to support a self-perpetuating and stable population. Benchmarks for maturation will be identified and tracked in the course of monitoring work, and reporting will identify whether supplement plantings or replacement plantings are needed if the original installations do not meet the success criteria. It must be recognized that a 'lag-time' between any planting effort and the achievement of an established, self-perpetuating population of desired plants is likely. Aggressive, sequenced planting of desired species may serve to speed up the colonization of the site, offset mortality of transplants, and provide structural complexity to the revegetated area during this lag period.

Success criteria for all plantings and overall restoration will be evaluated via monitoring (**Table 5**). Four types of monitoring will be included: 1) Revegetation Photo Point Monitoring, 2) Survivorship Monitoring, 3) Planting Method Assessment Monitoring, and 4) Habitat Assessment Monitoring (Monitoring design protocol details below). Monitoring will inform the maintenance and adaptive management of the revegetation efforts.

Success criteria related to rail occupancy in revegetated sections of the marsh must be calibrated to reflect the understanding that a healthy native marsh assemblage is unlikely to ever support the high rail densities observed in a non-native *Spartina* invaded system. The most likely positive outcome is that clapper rail densities post non-native *Spartina* removal will closely mimic site specific pre-invasion densities and population numbers. Occupancy by clapper rail at any level, as determined by yearly call count surveys using standard USFWS data collection and analysis protocols in the revegetated portion of the marsh is a medium term success criteria for the revegetation efforts (passive and active combined).

Longer term success criteria will center on the natural, passive dispersal and establishment of the reintroduced native plant(s) at other locations within the ISP revegetation sites. In addition to establishment of native marsh community, if pre-invasion or baseline data/photos are available, the target community will be site specific, pre-invasion plant and animal community assemblages. This will be most readily identifiable in the form of *S. foliosa*, which has either been extirpated from the area by the non-native *Spartina* invasion or not had a chance to establish in a newly opened/restored marsh. The presence of *S. foliosa* in any areas not specifically planted

Table 5: Proposed Success Criteria for Revegetation Effort for ISP Revegetation Sites

Timing	*Criterion*	*Description*
Short Term (2011-2012)	1A: Planting survivorship and vigor	Plants not only need to survive the initial planting (or be replenished in a second round of planting) but also need to thrive so they will eventually provide the habitat values sought. At least 40% survivorship is the target in this harsh estuarine environment.
	1B: Growth and maturation of plantings	Plants need to show significant growth and reach maturation. Metrics of success will be measured against the size of a given plant species at the location its seed or transplant was harvested.
	1C: Passive revegetation and regrowth of native marsh species	These sites should experience passive establishment of native plant species. This criterion is species specific and relates to the proximity of native plant populations to the site.
	1D: Planting and survivorship of host plant species for endangered *Cordylanthus mollis* spp. *mollis*	Success criteria specific to Southampton Marsh (Site 11). At least 30% cover of intra-site transplants of good *Cordylanthus mollis* spp. *mollis* hosts.
	1E: Passively restore pickleweed (*Sarcocornia pacifica*) habitat for endangered salt marsh harvest mouse (*Reithrodontomys raviventris*)	Successful establishment of extensive pickleweed marsh plain that will support the endangered salt marsh harvest mouse.
Medium Term (2012-2015)	2A: Plant density relative to reference sites	Species-specific metric determined by ground-truthing the native plant distribution at reference sites of a similar marsh type and region of the bay to the revegetation site.
	2B: Presence of vertical biotic structure providing clapper rail habitat	Rapid establishment and maturation of plantings should provide the target vertical structure and refugia favored by clapper rail.
	2C: Clapper rail presence as determined by call count surveys	Detection of clapper rails using the site.
	2D: Growth and maturation of host plant species for endangered *Cordylanthus mollis* spp. *mollis*	Success criteria specific to Southampton Marsh (Site 11). Refers to the development of intra-marsh transplants of appropriate host plants for the hemi-parasite including *Sarcocornia pacifica*, *Distichlis spicata*, or *Jaumea carnosa* where the *Spartina patens* was removed.
	2E: Establishment of *Cordylanthus mollis* spp. *mollis* from active seeding	Success criteria specific to Southampton Marsh (Site 11). Refers to the establishment of endangered *Cordylanthus* from active seeding in the area of *S. patens* removal after host plants have established (2D).
Long Term (2015-2020)	3A: Presence of self-sustaining plant populations (i.e., reproduction and recruitment of propagules from restoration plantings)	In monitoring areas not directly planted with the various natives (e.g. S*. foliosa*, *G. stricta,* etc.) the establishment of those species indicates successful intra-site dispersal from the mature plantings.
	3B: Stable (no decrease in number) and/or increase in clapper rail numbers as determined by call count surveys	Annual monitoring of the ISP revegetation sites through call count surveys during the breeding season should detect equal or greater numbers as compared to pre-revegetation
	3C: Development of tidal marsh community diversity	Significant increase of community diversity including a complex native plant community and habitat for species such as the salt marsh harvest mouse

Table 5: Proposed Success Criteria for Revegetation Effort for ISP Revegetation Sites

Timing	*Criterion*	*Description*
Maintenance Success Criteria	4A: Return to unvegetated mudflat or channel bottom at suitable elevations	Completion of the hybrid *Spartina* eradication in low-elevation areas successfully restores their natural condition as unvegetated mudflats or channel bottoms
	4B: Shorebird foraging/roosting on maintained unvegetated mudflats	The use of previously-infested mudflats by shorebirds for foraging or roosting completes the restoration of these areas
	4C: Removal and continued exclusion of non-native *Spartina*	Refers to maintenance of the eradication of non-native and hybrid *Spartina*
	4D: Removal and control of other invasive plants to the extent practicable with currently available methods and regulatory approvals.	Refers to the removal of secondary invaders within the marsh. High marsh transition zone planting areas will require monitoring and weed removal to allow for successful planting establishment. The initial goals will be to achieve and maintain <10% cover of invasive plants that are detrimental to the establishment of habitat for California clapper rails.
Establishing the Components of the ISP Revegetation Program	5A: Identification & formation of revegetation partner network	Coordination of nurseries for propagation, contractors for planting, landowners and managers, and other stakeholders involved in the Baywide revegetation effort
	5B: Development and implementation of revegetation plans	Completion of the plan with input from external review
	5C: Funding secured for projects	Secure funding for the various stages of the ISP revegetation effort including both short and long-term.
	5D: Research and development of best propagation and planting techniques	All pilot projects and subsequent work will be structured to determine the best possible techniques that can then be employed as efforts are ramped up to increase efficiency and speed habitat creation
	5E: Development and implementation of long-term monitoring plans	Completion of monitoring plan that incorporates baseline vegetative data for the ISP revegetation sites, enhanced clapper rail monitoring, and tracks the development of the revegetated marsh
	5F: Dissemination of results to Baywide restoration community	After data on the ISP efforts have been analyzed, they will be disseminated to other entities that may benefit from the work such as the South Bay Salt Ponds restoration

with this species will be considered as a successful outcome of the revegetation effort. To establish that native *S. foliosa* has indeed migrated from planted areas, the genetics of any *S. foliosa* planting areas and putative colonization sites will need to be monitored to ensure that hybrid *Spartina* is not allowed to establish and thrive. The genetic results should be compared to the data collected from the source population (either where plugs or seeds were harvested from) and tracked over time.

Another success criterion in the longer term will be the continued and expanding use by clapper rail of revegetated areas as determined by yearly call count surveys. In addition, the presence of any number of other tidal marsh wildlife species can be used to gauge the success of the revegetation efforts and the overall development of diversity in the marsh. The presence of species such as Alameda song sparrow (*Melospiza melodia*), common yellowthroat (*Geothlypis trichas*) and others will indicate the successful development of a diverse marsh community.

8. MONITORING PROTOCOL DESIGN

Four types of monitoring will be included in this program: 1) Revegetation Photo Point Monitoring; 2) Survivorship Monitoring; 3) Planting Method Assessment Monitoring and 4) Habitat Assessment Monitoring. A set of reference sites will also be monitored to help guide and adapt the planting plans and track passive revegetation. Baseline monitoring will take place prior to any revegetation efforts.

8.1. Revegetation Photo Point Monitoring

Permanent revegetation photo points will be established at the revegetation sites (both active and passive sites) prior to revegetation. Photos will be taken annually during the late summer-fall. A minimum of 2 photo documentation points per revegetation site will be established to document site conditions prior to revegetation. The location of the photo documentation site will be documented using GPS and possibly marked with PVC pipe to facilitate relocation. The revegetation photo points should include landscape features that are unlikely to change over several years (buildings, other structures, and landscape features such as levee berms, trees, foot bridges, etc.) again, to facilitate relocation of the photo position.

Photos will be taken from these revegetation photo points at the same camera angle each monitoring year, using a north, south, east, west compass bearing axis at the selected photo points, as appropriate to illustrate site conditions. Photographs will be taken from approximately 5 ft in height.

8.2. Survivorship Monitoring

Planting survivorship monitoring will take place annually in the late summer-early fall. All plantings locations will be noted using GPS.

Using the total planting points/areas, the appropriate sampling number can be determined using a power analysis. The power analysis will measure percent survivorship to within a margin of error of 10% at the 95% confidence interval (i.e., assesses percent survivorship to within +/- 10% of the true value, with a 95% likelihood of covering the true value in that range). The proposed power analysis method will include the development of a monitoring protocol describing data collection techniques and sub-sampling across the different planting areas, sites types and marsh zones (as defined earlier in this document).

An a priori power analysis will be used to determine the monitoring effort required for the statistical analysis. The design of the statistical analysis influences the power analysis, including: specific question to be answered and related statistical parameters (i.e. is the true value of the percent cover less than or equal to the percent cover requirement).

The allowable certainty for percent cover will be a margin of error of +/- 10% at the 95% confidence interval. The confidence interval is the probability that the true value would be within the margin of error around the reported percentage; the lower the confidence interval, the smaller the margin of error. Margin of error (ME), confidence interval and required number of sampling points (n) are related by the following equation for the 95 % confidence interval:

The number of sampling points required to evaluate survivorship will be calculated using this equation:

$$ME = 0.98/\mathrm{sqrt}(n)$$

Using GIS, the statistically appropriate number of a randomly selected sampling points or plots of planting areas will be used to conduct the annual survivorship surveys. We will use a stratified random sampling technique to determine the location of permanent survey plots. The number of sampling plots depends on the vegetation community, final number of plantings, number and size of planting areas, data collection method and spacing of plantings. Data must be collected at 3 or more sampling plots to allow for statistical analysis. Since some of the habitat types that are being revegetated are in very narrow bands, it is possible that the plots will not fall within each habitat type. Plots will be randomly stratified across marsh planting zones (as noted above).

At each planting area or sampling plot, (1 meter^2), each live planted species will be counted and each species will be recorded. In addition, observations regarding plant health (e.g., vigor, evidence of herbivory, evidence of dieback shoots, severe insect infestation, etc.) will be noted, particularly when poor health is an apparent indicator of imminent mortality.

A t-test will be used to evaluate whether or not percent survivorship is less than or equal to the interim or final success criteria.

8.3. Planting Method Assessment Monitoring

The overall health and vigor of the plantings will be monitored as an assessment of the efficacy of the planting methods across marsh planting zones. The number of sampling points will be determined using the power analysis method above. Data will be collected annually in late summer to early fall. 1 meter^2 plots will be set and the following data parameters measured: maximum plant height (*S. foliosa or G. stricta*); # culms (stems *S. foliosa*); maximum plant diameter (*G. stricta*); plant life history (vegetative, flowering, seeding, senescing, etc.); absolute vegetative percent cover, species percent cover (native and non-native); percent cover bare ground; and percent cover wrack or other. All monitoring plots will be photo monitored (photo point established).

Planting methods experiments may include:

- source plant location;
- source plant salinity/inundation regime/soil type;
- source plant size (e.g. age, life history);
- propagation technique (e.g. transplant, vegetation bed, seed);
- planting technique and design (e.g. planting density);
- other

A t-test will be used to evaluate whether or not percent cover is less than or equal to the interim or final success criteria. Trend analysis may be more informative than examining threshold exceedance because species percent cover increases often are predictive of long-term ecological composition. Trend analysis would be conducted as described for planting survivorship with the caveat that annual climatic variation may influence the percent cover.

Qualitative vegetative data will be collected each year at a sampling of all active and passive revegetation sites with the purpose of informing management and future revegetation efforts. These general site assessments are intended to assess the overall functioning of the site as a whole, and also to help identify localized or low-level trends such as new invasive species formations, localized changes in species abundance, and other revegetation or weed control man-

agement actions. Related observations of vegetation and habitat condition will be noted, including: patterns of plant die-offs, erosion, hydrological issues, herbivory, or other land use issues. This information is intended for use in recommending management actions as necessary.

8.4. Habitat Assessment Monitoring

Habitat Assessment Monitoring will include measuring a number of marsh parameters that are indicative of the overall marsh habitat quality and structure. As there will be a considerable lag time before significant habitat changes can be detected across all sites, Habitat Assessment Monitoring will take place every 3-5 years during April-May.

Habitat Assessment Monitoring will take place on both active and passive revegetation sites. In comparing the relative rates of revegetation, and the change in habitat structure, this monitoring effort will illustrate the efficacy of the active revegetation methods. This information will also be used to further guide the revegetation program design.

Habitat Analysis Monitoring will involve using GIS to create a 25 x 25 meter grids across the Clapper rail habitat area boundary (defined by the ISP Clapper rail monitoring program). The entire site (Clapper rail habitat) area will be divided by marsh zones (as described above) (1) high marsh channel edge; (2) mid-marsh zone; (3) low marsh channel edge; (4) upland transition zone; and (5) low marsh zone. Each grid will be monitored for percent cover of the 10 dominant species. In addition, each strata will be further monitored using a 1 meter by 1 meter quadrat. Dowel/Quadrats data will monitor plant species, species cover, plant density at 25 centimeter height intervals. Each monitoring point will be marked using a GPS unit and PVC pipe to facilitate returning to the monitoring location in future years.

Vegetation cover will be assessed using aerial photos if available to supplement other data collection methods.

8.5. Monitoring Schedule

Habitat Analysis monitoring will take place from April through May, and Revegetation Photo Point, Survivorship and Planting Method Assessment Monitoring will take place in August to October. Some flexibility will be needed to account for annual variation in weather conditions.

9. MAINTENANCE

The ISP is, in a very real sense, the cost of deferred maintenance on previous restoration and revegetation work in the San Francisco Estuary. The initial introduction of non-native *Spartina* done by the Army Corps of Engineers was a revegetation activity that was unmaintained. The restored tidal marshes where the ISP does much of its work were opened to tidal action with insufficient maintenance strategies in place to keep non-native *Spartina* from invading or to control it once it came in. As a result, it was necessary to create the ISP at great and continuing cost to remediate the effects of these un-maintained revegetation and restoration efforts.

Committing to a maintenance strategy and budget is an integral component to any successful revegetation effort. The maintenance strategy associated with the effort should be integrated into all aspects of the project, from planning to implementation to the actual maintenance phase. Pilot project work will more clearly define the overall cost structure for subsequent planting seasons beyond the 2011-2012 season, but a solid maintenance strategy and proposed methodology could be in place much earlier.

Much of the maintenance effort for native *S. foliosa* plantings will be related to the control of non-native *Spartina* proximate to the planted areas. This responsibility is already within the scope of responsibilities of the ISP's *Spartina* Control Program and partnerships and would not need to be significantly modified to include the areas of the marshes proposed for revegetation efforts. The areas that are planted with *G. stricta* and/or other marsh plant species will likely require maintenance work beyond the current purview of the *Spartina* Control Program, in that other non-*Spartina* weed species may require control to enhance the success of the plantings. East Bay Regional Parks District, Save The Bay, and others will work with the State Coastal Conservancy to control any other non-native species that threaten the success of the revegetation effort.

Components of the revegetation management strategy:

- Respond to and control non-native weedy plant species that have the potential to invade planted areas. Examples would include:
    - *S. alterniflora x foliosa* (smooth cordgrass hybrids)
    - *Lepidium latifolium* (perennial pepperweed, whitetop)
    - *Limonium ramosissimum* (Algerian sea lavender) and hybrids
    - *Raphanus raphanistrum* (wild radish)
    - *Foeniculum vulgare* (wild fennel)
    - *Carpobrotus spp.* (iceplant)
    - *Salsola soda* (saltwort)
    - Other weedy species as necessary
- Limited control of native plant species that may decrease the success of planted areas
- Limited irrigation of planted seedlings, especially *G. stricta* or others planted on higher elevation zones less regularly inundated with daily tides
- Control of herbivory where practicable (e.g., caging seedlings to minimize Canada goose grazing)

Each of these items will have an associated cost that will be better defined during pilot project operations. Each site will have specific maintenance needs that will need to be analyzed and defined for long-term success of the effort.

10. MONITORING REPORTS

Brief annual reports will be provided to the U.S. Fish and Wildlife Service. The reports will assess progress toward short, medium and long term success criteria and performance objectives. Photographs of revegetation site shall be included in annual reports, as necessary, to document site conditions.

11. CONTINGENCY MEASURES

If a short or medium performance criterion (averaged over sample plots) is not met for any year, or if final criteria are not met, a report will be prepared analyzing the cause of failure and, if necessary, proposing further revegetation, modifying management strategies or methods, or other.

12. BUDGET AND FUNDING

12.1. Budget Estimate

A conservative estimate of per-plant costs, fully-burdened to include all aspects of collection, propagation, planting, monitoring, maintenance and project management would be on the order of $5.00 per plant (regardless of species or methods). Assuming 49.72 acres to be revegetated over the 5 years covered in this plan, and further assuming one plant per square meter (4046.9 m^2 per acre), the estimated budget would be $1,066,112.82, to plant 213,223 plants. The 1 plant per square meter estimate is based on an average of the *S. foliosa* (4 per meter) and *G. stricta* (2 per meter) planting densities projected over the total acreage to be revegetated at each site.

Pilot project efforts (2011-2013) encompassing the methods described above would be aimed at developing a defined cost structure for the remainder of the revegetation effort, and subsequent work would refine that number. For the pilot project work, ca. $700,000.00 should serve as sufficient seed capital to initiate each of the various stages of the pilot-scale revegetation plan work from October 2011- March 2013, and finalize strong design and monitoring criteria for a scaled-up approach in future years. In year three and subsequently until the project reaches a self-sustaining condition that satisfies the success criteria described above, a very general estimate of $300,000.00 per year investment could be envisioned.

Previous revegetation efforts have been underway since 2006 (examples in **Figures 4-8**), and we are assessing the cost of these to help with a long-term estimate. The pilot efforts include mid-marsh plantings with Save The Bay at Arrowhead Marsh; with Friends of Corte Madera Creek at Creekside Park; and pilot *S. foliosa* plantings at Elsie Roemer Marsh and Colma Creek. We are planning to continue getting monitoring information and assess success of existing 2010-11 *S. foliosa* and mid-marsh plantings.

12.2. Program Funding

The State Coastal Conservancy is committed to securing state bond funding for 2011-13 pilot revegetation at Arrowhead Marsh and up to 19 other sites. Management staff are targeting the September 22, 2011 State Coastal Conservancy Board Meeting, and expect to bring a staff recommendation before the board for roughly $1,000,000 that would fund multiple partners. This funding would support the first two years of expedited pilot revegetation efforts, as well as to hire technical consultants to analyze opportunities, costs, feasibility, and permitting for the creation of flood refugia and further pilot floating islands at additional sites.

The State Coastal Conservancy, East Bay Regional Park District, Save The Bay, Friends of Corte Madera Creek, and the California Wildlife Foundation will be developing a USFWS National Coastal Wetlands Conservation Program proposal for submission June 2012 to apply lessons learned from the 2006-2013 pilot projects and fund scaled up revegetation projects at up to 39 sites from 2013-2016. By taking this methodical and iterative pilot scale approach that involves multiple agencies, landowners, community-based organizations, and technical partners; we are confident that we will be successful with large-scale revegetation based on the outcomes of the pilot work from 2006- March of 2013.

A future draft of this document will be submitted for an external scientific review to a Technical Advisory Committee. After receiving comments we expect to modify and improve the Revegetation Plan prior to implementation.

13. EXAMPLES OF EARLY REVEGETATION PROJECTS

Figure 4. *Grindelia* and *Triglochin* plantings at Arrowhead Marsh West, Oakland, 2010. The collaborative effort was coordinated by Save the Bay. *Right*: Members of the planning and implementation team (from left to right): Jeanne Hammond, Invasive *Spartina* Project; Laura Wainer and Denise Della Santina, Save the Bay; Peter Alexander, East Bay Regional Parks District; Toby Rohmer, Invasive *Spartina* Project; and Cory Overton, US Geological Survey.

Figure 5. Left: High tide refugia planting on the upland edge of the newly-opened Eden Landing preserve. Right: Three generations of refugia plantings at MLK New Marsh. Both sites are in the San Leandro Estuary in Oakland.

Figure 6. Channel construction and Grindelia planting at Elsie Roemer Wildlife Sanctuary, Alameda. Channels with berms were built in 2006 to provide marsh elevations suitable for native marsh vegetation after removal of extensive hybrid *Spartina* meadows. Grindelia was planted in 2007 and 2008, and annual and perennial pickleweed established naturally. In 2011, once the hybrid was predominantly under control, experimental plants of *Spartina foliosa* began (figures 4 and 5).

Figure 7: Collection of *Spartina foliosa* plugs at Harriet Mundy in Palo Alto, CA in 2011. Picture on right shows DNA collection. For each donor site, 12 DNA samples were taken.

Figure 8: Planting *S. foliosa* at Colma Creek in South San Francisco. Site was planted with 2 donor populations of *S. foliosa. Right*: Complete *S. foliosa* plot. 60 plots were planted at Colma Cree, and 75 were planted at Elsie Roemer, in Alameda.

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